TUNGSTEN-POLYMETALLIC-AND BARITE-MINERALIZED ROCKS IN THE RUBY MOUNTAINS, NEVADA

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ABSTRACT

Mineralized occurrences in the Ruby Mountains were examined for any inferred traces of gold-ore-forming fluids that might be connected to metamorphism and to formation of Carlin-type gold deposits at a higher structural level. Traverses across the metamorphic core complex of the Ruby Mountains and study of known tungsten-polymetallic and barite deposits revealed skarn as predominant type of mineralized rock. At least two phases of skarn formation are present: (**1**) an early phase connected with a Late Jurassic granitic intrusion, and (**2**) a later phase related to Oligocene granite-monzonite of the Harrison Pass pluton. Skarn deposits of both phases are present at generally the same stratigraphic level in Cambrian marble and recrystallized limestone and contain similar Pb, Zn, Cu, Ag, Ba ± W mineralization. The main differences consist of variable compositions of the skarn assemblages: first, pyroxene-idocrase with minor garnet and a retrograde association of amphibole (actinolite-tremolite)-epidote-calcite accompanied by quartz-sulfide minerals; second, an amphibole-epidote-garnet skarn assemblage with a calcite-quartz retrograde association. This difference and varied ore textures, almost "epithermal" in the second case, have been probably caused by different depths of emplacement of the accompanying intrusions: deep Jurassic pegmatitic granite and shallow Tertiary pluton. Celsian, a barium plagioclase feldspar, was newly discovered in skarn deposits of both ages. Ore-host Cambrian carbonate rocks might have contained pre-metamorphic barite-bearing SEDEX(?) mineralization or the celsian might be a granite-generated component of the skarn-polymetallic-barite assemblage.

Combined vertical zoning of early first phase skarn can be traced for deposits of the Battle Creek Mine (2,220 m elevation), American Beauty Mine (2,460 m) and Knob Hill Mine (2,610 m), which are present in a roof pendant in a Jurassic pegmatitic granite. Tungsten and quartz-polymetallic mineralized rocks at the Battle Creek Mine are hosted by well-developed skarn. At the American Beauty Mine, at 240 m higher elevation, mineralized rock is characterized by a polymetallic sulfide assemblage without tungsten and is accompanied by quartz containing only fragments of skarn that are almost entirely destroyed by retrograde processes. Approximately 150 m higher at the Knob Hill Mine, upper levels of the mineral zonation contain only quartz-polymetallic veins surrounded by a halo of hydrothermal silicified rocks and carbonate-altered rocks. Gold is not a significant component of skarn mineralization. Rcognition of this vertical zonation of the skarn deposits seemingly does not allow space for any "skarn roots" for Carlin-type gold mineralization in the deeper crust represented by this migmatitic core.

Two types of barite mineralization are present in the Ruby Mountains: bedded barite at the Judy Mine which is present in Devonian dolomite in the southern part of the range, and vein and replacement barite mineralization which partially resulted from remobilization of earlier bedded barite during Tertiary extensional-related hydrothermal activity. The bedded barite might be roughly comparable to recently discovered minor barite-bearing SEDEX-type base and precious-metal mineralization in Devonian strata of the northern Carlin trend. However, an absence of base and precious metals in the bedded barite places limitations upon such comparisons. Barite is an insignificant but common component of many Carlin-type deposits. The same reasoning applies to comparison of vein-type barite occurrences in the Ruby Mountains with proximal minor barite-bearing Carlin-type deposits in the area of the Alligator Ridge and Yankee gold mines, south of the Ruby Mountains. These latter occurrences are commonly located in Mississippian strata.

Thus, this study did not demonstrate in Ruby Mountains any "roots", connections, or deeper analogs for Carlin-type gold deposits. However, the investigation did provide a clear understanding of the largely pluton-related mineral deposits of this prominent metamorphic terrane.

INTRODUCTION

Scattered ore deposits in the metamorphic core complex in the Ruby Mountains provide an opportunity to examine the potential association between gold-ore-forming fluids and metamorphism as well as any association with Carlin-type gold deposits, which would have formed at higher structural levels in the crust. The work was initiated with the intention of either confirming or clarifying underlying assumption to the hypotheses of metamorphogenic (Seedorff, 1991) or amagmatic (Ilchik and Barton, 1997) origins of Carlin-type gold-forming fluids.

The Ruby Mountains are located in Basin and Range province of northeastern Nevada. The range formed as a late Cenozoic north-northeast-trending horst extending 115 kilometers at an angle of about 35° to the Carlin trend, whose southeastern extension crosses the southern end of the range (fig. 1). The metamorphic core complex exposed within the Ruby Mountains was the main object of field observations. Previous studies of the geologic, tectonic and magmatic history of this terrane by many others (Howard, 1966, 1971, 1980; Howard and others, 1979; Kistler and others, 1981; Snoke, 1980, 1997; Snoke and Miller, 1988) provided the framework for this mineral-resource investigation.

Fieldwork undertaken as part of this study examined the areal metasomatic events in metamorphic rocks that could be interpreted as evidence of widespread fluid activity, and documented the different types of mineralized rocks in the Ruby Mountains. The studies had two tasks: (**1**) to identify possible analogs to Carlin-type gold deposits, and (**2**) to determine spatial and temporal relationships of mineralized rocks to metamorphism. The first task was carried out by traverses across the Ruby Mountains. The second task required a first-hand acquaintance with deposits of the Ruby Mountains and Carlin-type gold deposits. The following accessible mineral deposits in the Ruby Mountains were examined: skarn-polymetallic±W deposits of the American Beauty Mine, Knob Hill Mine, Battle Creek Mine, Valley View Mine, and Summit View Mine; and barite deposits of the Judy Mine, B & P claims, and Dorsey Canyon prospect (fig. 2). Follow-up study included rock and ore microscopy, scanning electron microscope (SEM) and microprobe analysis, and preparation of samples for U–Pb age and Pb isotope determinations, and for sulfur-isotope analyses of barite. Preliminary results of the study are presented herein.

GEOLOGIC FRAMEWORK

Stratigraphic Units

The prominent deeply eroded Cenozoic horst of the Ruby Mountains is composed of different and contrasting rock complexes. According to Howard (1966, 1980); Howard and others (1979); Snoke (1980, 1997); Snoke and Miller, (1988); MacCready and others (1997), rocks in the range can be subdivided into two main units. A migmatitic core complex makes up the core of the Ruby Mountains. It consists of metaquartzite, pelitic schist, gneiss, and marble metamorphosed to upper amphibolite facies, with an indicator mineral association of sillimanite-muscovite-K–feldspar. Howard (1980) consided the protoliths of this complex as Early Cambrian and Precambrian(?). Kistler and others (1981) argued that the metamorphic complex is chiefly Precambrian >1,450 Ma, and has been metamorphosed and intruded by granite-granodiorite gneisses at about 550 Ma. Lush and others (1988) reported a Late Archean age (2.5±0.11 Ga) from a sample of orthogneiss in the adjoining East Humboldt Range. It seems noteworthy that the Precambrian part of this unit was not outlined on geologic maps of the Ruby Mountains. Old stratigraphic boundaries are obliterated by superposed polyphase magmatic and metamorphic events, and the possibility of delineating the Precambrian rocks within the core complex remains questionable. Thus, we focused our field observations generally on the entire migmatitic metamorphic sequence keeping in mind that it includes Paleozoic metasedimentary rocks, correlative with the miogeoclinal sequence of the eastern Great Basin (Howard, 1966, 1971).

Unmetamorphosed to low-metamorphic grade Cambrian to Triassic carbonate and clastic rocks compose the second main unit. These rocks are typical miogeoclinal sequences that continue southward into the southern part of the Ruby Mountains, south of granite exposures. Separate low-angle fault-bounded packages in the central and northern part of the range are made up of similar sedimentary rocks. Fossiliferous dolomite and limestone compose a substantial part of the unit. Tertiary clastic sedimentary rocks and rhyolitic volcanic rocks dated at approximately 15 Ma were involved in a low-angle fault complex and cut by detachment faults in the northern Ruby Mountain (Snoke, 1980; MacCready and others, 1997).

Magmatic Events

The horst in the Ruby Mountains appears to be a distinctive plutonic terrane (Howard, 1966, 1980; Kistler and others, 1981). Wide areal exposures of Mesozoic and Cenozoic granitic rocks in the central part of the range are surrounded northward by a migmatitic core complex. The latter appear like a roof pendant in a giant polyphase granitic intrusion that has been eroded and partially exhumed. Metasedimentary rocks are intercalated with numerous sills and cut by dikes of pegmatitic granite, the proportion of which increases downward. Phanerozoic magmatic successions of the Ruby Mountains include four main events.

(**1**) Pegmatitic granite predominates the Late Jurassic intrusive complex. It is accompanied by sparse gabbro and quartz diorite to trondjemite and biotite granodiorite. The presence of garnet in the metamorphic mineral assemblage and the gneissic texture are typical of these rocks. A Rb–Sr age for the pegmatitic granite is 159.7±2.7 Ma (Kistler and others, 1981) whereas a U–Pb monazite age of 153±1 Ma (Hudec and Wright, 1990) is slightly younger.

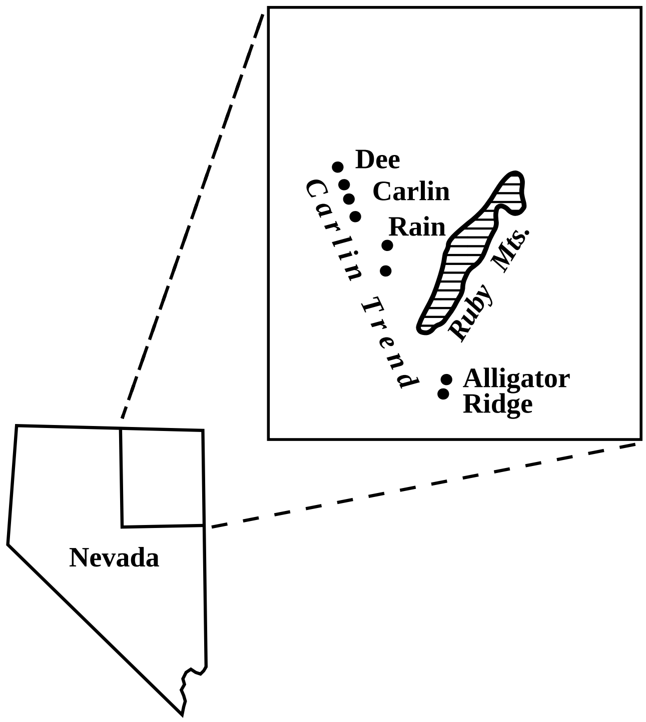


Figure 1 Location of the Ruby Mountains (hatched) in relation to the Carlin trend, Nevada.

(**2**) Cretaceous two-mica leucocratic granite has intruded the pegmatitic granite and is present as a subsidiary igneous phase mainly inside the Jurassic pluton in the central Ruby Mountains. A Rb–Sr age determined by Kistler and others (1981) is 83.9±1.25 Ma.

(**3**) The Oligocene granite-monzonite of the Harrison Pass Pluton intrudes the older rocks. A Rb–Sr age of 31.9±1.2 Ma has been determined by Kistler and others (1981) for these rocks. Cataclastic textures are characteristic for these rocks, and they are locally overlain by a klippe of unmetamorphosed Paleozoic sedimentary rocks. Wright and Snoke (1993) indicate that Tertiary intrusive rocks are widespread and make up a significant component of the metamorphic core complex in the northern Ruby Mountains. They report U–Pb ages between 40 to 29 Ma for 48 zircon and monazite fractions from granitic rocks, varying from quartz diorite to leucogranite in composition.

(**4**) Various other igneous rocks are assigned Late Tertiary ages (Snoke, 1980, MacCready and others, 1997). This group of rocks includes scattered basalt dikes with chilled margins that intruded mylonitic metamorphosed rocks at about 17–15 Ma, and felsic volcanic rocks in the northern Ruby Mountains, which were erupted about 15 Ma. The felsic volcanic rocks are similar in age to rhyolite flows near the northern terminus of the Carlin trend (Fleck and others, this volume).

In a road cut along Lamoille Canyon, dikes of granite porphyry that probably belong to the last magmatic event are well-exposed (fig. 3). The exposure is situated inside a transition mylonite zone, in the western edge of the Lamoille Canyon nappe outlined by Howard (1966, 1980) as a pre-metamorphic thrust structure. Flaggy micaceous quartzite interbedded with biotite schist contains a tectonic lens of contorted marble, partially replaced by diopside. Metasedimentary rocks dip gently 15° to N10°E, and are intruded by boudinaged sills of pegmatitic granite. Overprinted blastomylonite fabric in pegmatitic granite is emphasized by foliated biotite (fig. 4*A*).

Wedge-like dikes of granite porphyry as much as 1.7 meters thick intersect the metasedimentary rocks and pegmatitic granite sills dipping 40° to E30°S. The fine-grained quartz-K–feldspar matrix of the granite porphyry contains phenocrysts of zoned plagioclase and quartz (fig. 4*B*). The ductile flow fabric of the matrix is parallel to sharp margins of the dikes. The shape and fabric of the dikes indicate that they intruded brittle fissures formed during extension. They might be a subvolcanic analog of the Miocene rhyolite mapped farther northward (Snoke, 1980). The dikes have not been affected by metamorphism or mylonitization and are considered as post-metamorphic and post-deformational. They, thus provide constraints on the minimum age of important geologic events in the Ruby Mountains.

Metamorphic and Structural Features

Regional metamorphism of the sedimentary and igneous protoliths, their relation to the structural evolution of the Ruby Mountains, and the development and timing of a remarkable mylonitic transition zone are described by Coats (1987); Dallmeyer and others (1986); Dokka and others (1986); Howard (1966, 1980); Hudec (1992); Hudec and Wright (1990); Lush and others (1988); MacCready and others (1997); Snoke (1980, 1997); Snoke and Miller (1988); and Wright and Snoke (1993). The geologic sequence defined in these studies is summarized below. Chronologic data favor a Tertiary age of metamorphic and deformational events (MacCready and others, 1997).

Formation of structural and metamorphic patterns in the migmatitic core complex includes (**1**) large-scale recumbent folding and thrusting, (**2**) polyphase amphibolite-facies metamorphism and deformation, and (**3**) intrusion of pegmatitic granite and related migmatization in the late Jurassic around 160 Ma. The latter was a period of major crustal shortening and thickening in northeast Nevada. Details of the earlier events were strongly masked or even destroyed by a substantial Tertiary thermal and tectonic overprint.

The migmatitic core complex is overlain by a kilometer-scale mylonitic shear zone (the so-called “transition” zone of Howard, 1980) traced for >100 km along the west border of

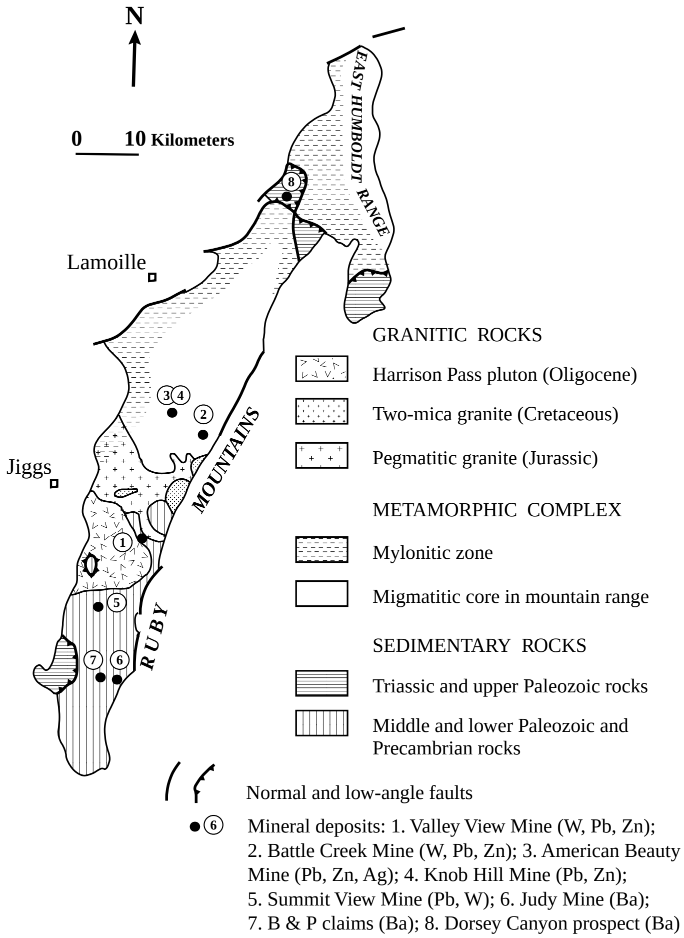


Figure 2 Distribution of mineral deposits studied in Ruby Mountains, Nevada. Geology simplified from Howard (1980); Howard and others (1979).

the Ruby Mountains. Intense ductile deformation, normal sliding and west-northwest trending streaky lineation of blastomylonitic fabric are characteristic of this zone. Variable mylonitic shear zones cutting metamorphic and granitic rocks beneath the main zone diminish with structural depth eastward. According to the geochronologic data, mylonitization developed mainly between 29 and 23 Ma and was superposed on 36–Ma Oligocene granitoids (Snoke, 1997; Wright and Snoke, 1993). In addition, 17- to 15-Ma Miocene basalt dikes cut the mylonite zone and were not affected by mylonitization. They constrain the minimum age of the ductile deformation.

Sheets of unmetamorphosed or low-grade Paleozoic and locally Tertiary rocks bounded by low-angle faults record late, post-mylonitic brittle detachment faulting. These structures are truncated by high-angle normal faults bordering the horst of the Ruby Mountains in some places.

In Search of Regional Metasomatic Events

During our traverses across the various structures that comprise the Ruby Mountains, we tried to find some traces of regional alteration that could be interpreted as a deep root for a Carlin-type fluid system. Decalcification, silicification, argillization, and at least sericitization are considered the main rock alteration around Carlin-type deposits (Bagby and Berger, 1985; Christensen, 1996; Cox and Singer, 1986; Theodore, 1997). Though these alteration types are typical of the structural level of Carlin-type gold ore deposition, we searched for any manifestations of the above-types of alteration as well as any other types of rock alteration.

Traverses across the metamorphic core complex demonstrate that two types of metamorphic rocks are regionally pervasive: (**1**) ubiquitous migmatic granitic material composes

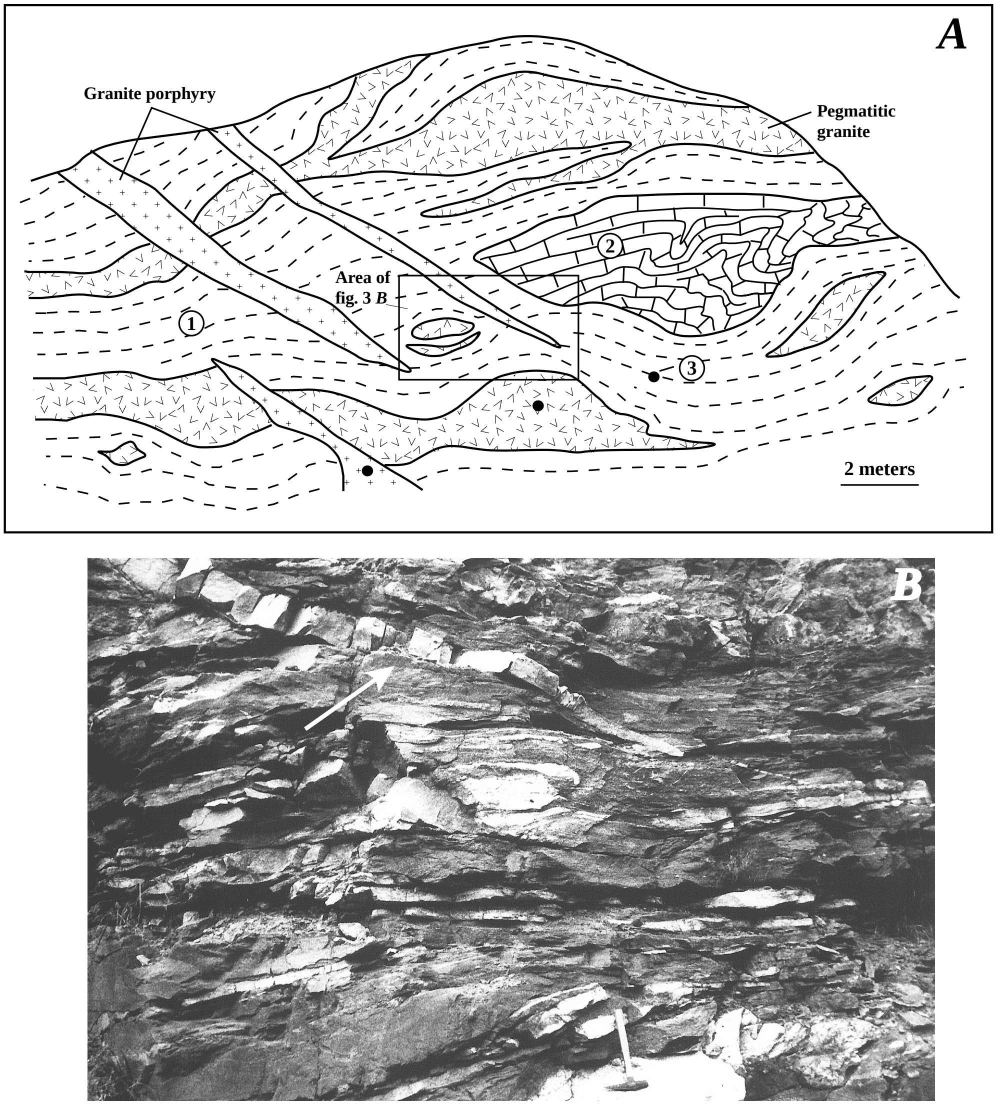


Figure 3 (***A***) Post-metamorphic and post-deformational wedge-like granite porphyry dikes in road cut in Lamoille Creek Canyon, 1 kilometer south of the Gaging Station, looking northeast. Sketch showing intersection with (1) schistose quartzite and metapelite; (2) marble; containing boudinaged sills of pegmatitic granite; (3) locality of samples for U–Pb age determination. (***B***) Photograph of area outlined in A.

no less than half of the exposed rock volume of the central and northern Ruby Mountains; and (**2**) local pyroxene skarn lenses are widespread in highly deformed beds of marble and crystallized limestone at contacts with sills and dikes derived from a pegmatitic granite. Skarn lenses underwent deformation and superposed boudinage, and subsequently cut by pegmatitic veinlets and accompanying quartz veins in some places. As a rule, these skarns are barren, but we have found sparse scheelite grains in alluvium-concentrate samples along creeks draining areas of skarn localities.

TUNGSTEN-POLYMETALLIC MINERALIZED ROCKS

The following accessible skarn-polymetallic ± tungsten deposits in the Ruby Mountains were examined in detail: Valley View Mine, Battle Creek Mine, American Beauty Mine, Knob Hill Mine, and Summit View Mine, which are located in different parts of the range (fig. 2). All these deposits are small. They were explored and partially mined to varying degrees by open cuts, adits, and shafts during previous years, and the walls

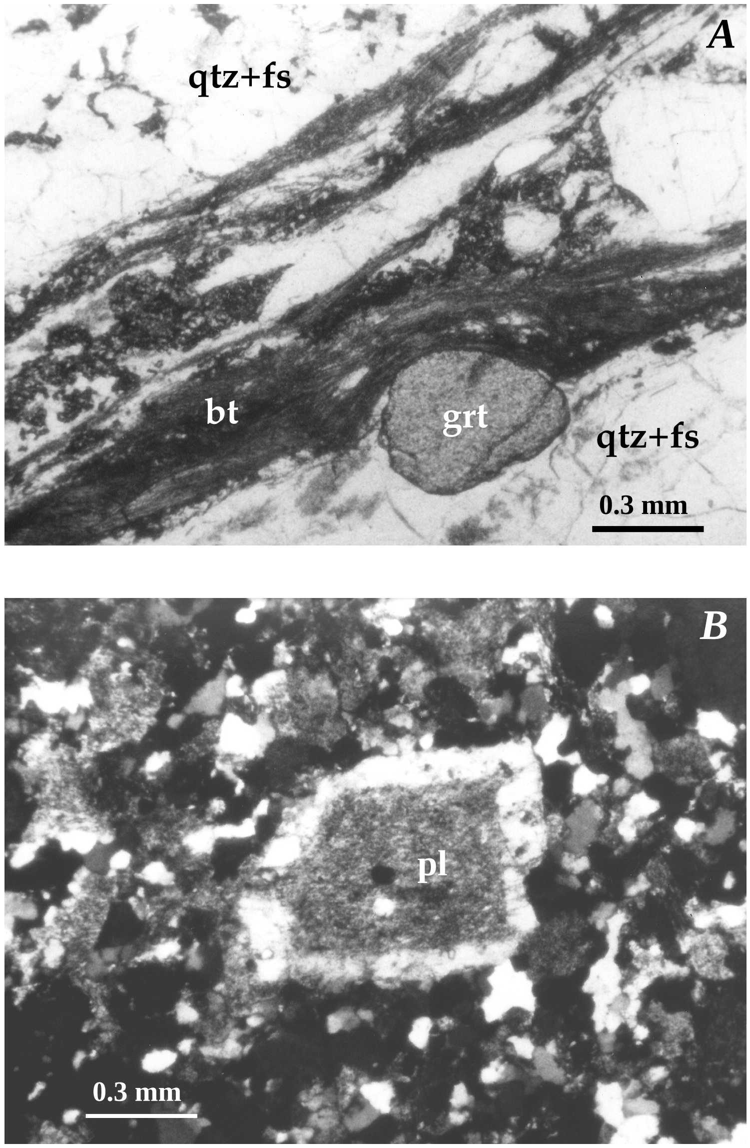


Figure 4 Photomicrographs of thin sections of samples from the outcrop shown on figure 3. (***A***) Mylonitic pegmatitic granite, plane-polarized light; (***B***) post-deformational granite porphyry, crossed nicols; qtz+fs, quartz and feldspar; bt, biotite; grt, garnet; pl, phenocryst of zoned plagioclase.

and faces of the old surface workings and dumps were generally accessible for examination.

The following general features characterize the deposits: (**1**) The deposits are present within Cambrian (and Ordovician in some places) marble, as much as 3,000 meters in tectonic thickness (Howard, 1980); (**2**) Exoskarn is predominant and present near or in the immediate contact with Late Jurassic and Tertiary granitic rocks; (**3**) The shape of the ore bodies varies from stratiform, and concordant to the marble bedding, to tabular to lensoid, and discordant to the bedding and concordant to a granite contact; (**4**) Evidence of pre-ore brecciation and ore-accompanying retrograde alteration of skarn is common; and (**5**) Scheelite and polymetallic sulfide assemblages are close in time and spatially, but commonly, are present as separate ore bodies.

All information about exploration and mining activity, processing and production, as well as brief geologic data, especially about tungsten mineralization, is summarized from published descriptions of mineral deposits (Bentz and Tingley, 1983; Lapointe and others, 1991; Smith, 1976; Stager and

Tingley, 1988) and supplemented by our observations.

Valley View Mine

(Valley View district, Road Canyon area)

The Valley View deposit (fig. 2, location 1) was discovered in 1913. Tungsten and base-metal ores were explored by adit, open cut, and a vertical shaft. Small amounts of tungsten were produced intermittently in 1944, 1953–54, 1957 and 1978, totaling 263 units of WO_3 (a unit of WO_3 is equivalent to 1 percent of a short ton, or 20 pounds of WO_3) from ore that graded from 10 to 0.6 weight percent WO_3.

The deposit is present inside a northwest trending 0.5–1.5-km strip of Cambrian crystalline limestone and quartzite dividing plutons of Jurassic pegmatitic granite and Tertiary Harrison Pass pluton of granite-quartz monzonite. A stratabound mineralized skarn zone 1–6 m in width is exposed intermittently over a strike length of approximately 150 m. Irregular skarn pods and seams are confined to a distinct bed of streaky carbonaceous siliceous marble and crystalline limestone, about 50 m wide striking west-northwest and dipping 75° N (figs. 5*A* and 6). Sills and dikes of granite, microdiorite, and quartz monzonite cut rocks in the general area of the deposit.

Most tungsten ore was mined from one mined-out skarn seam 1–6 inches wide and 48 feet in length along the contact between crystalline limestone and quartz monzonite sill. The scheelite ore of this seam was estimated to contain from 1 to 5 weight percent WO_3 and yielded 150 units of WO_3. Scheelite is present in skarn consisting of diopside, epidote, calcite and quartz. Bismuthinite and native bismuth were found in the aggregate with pyrite and quartz in the centers of some granitic sills.

Stratabound skarn sulfide tabular bodies, exposed in the open cut (figs. 5*A* and 7*A*-*B*), consist mainly of oxidized ore. Disseminated sulfide grains and pods are present in siliceous crystallized biotitic limestone partially replaced by clinopyroxene and epidote. Grains of the earliest pyrrhotite, as much as 0.01 mm wide, are present along limestone bedding planes independent of any skarn minerals. Where minerals of the skarn assemblage accumulated, pyrrhotite is partially or entirely replaced by pyrite, chalcopyrite, sphalerite, and galena, in this succession. These sulfides are part of a retrograde skarn assemblage that is associated with epidote and quartz. They replaced the earlier and probably metamorphic pyrrhotite.

Quite distinctive of this sulfide skarn zone is a replacement of most widespread galena and sphalerite by late actinolite (fig. 8*A*-*B*). This substitution has led to drastic dilution of the sulfide ore. Quartz and epidote accompanied deposition of the major part of this sulfide assemblage. In addition, pre-sulfide pyroxene was replaced by an aggregate of lance-shaped crystals of amphibole. It looks like a superposition of a new hydrous amphibole skarn assemblage on an earlier skarn and retrograde quartz-sulfide mineralization, which is interpreted to have been related to the Late Jurassic pegmatitic granite. The late amphibolization probably represents a second period of skarn formation associated with the nearby Tertiary Harrison Pass pluton, which is known elsewhere to have related amphibole-garnet-epidote skarns (fig. 2).

Battle Creek Mine

(Ruby Valley district)

The Battle Creek deposit (fig. 2, loc. 2) is located on the east side of the Ruby Mountains at an elevation of about 7,400 feet (2,220 meters). It includes several mineralized skarn zones spread over an area of about four square kilometers. The deposits were discovered in 1903; base metal and incidental silver and gold were produced during a period from 1908 until 1967, and since 1949 shipped ore averaged 55 weight percent Pb and 14.2 weight percent Zn. Tungsten had been detected in 1943 and produced intermittently from 1944 to 1977, the ore averaged 1.5 weight percent WO_3 during 1944–45. Exploration and mine workings consist of numerous trenches, an open cut, two shallow shafts, and four adits with a total 700 feet of underground workings. Total production from the Ruby Valley district is as follows: tungsten, 4,944 units; lead, 531,135 lbs; zinc, 250,300 lbs; copper, 24,413 lbs; silver, 11,332 ounces; gold, 56 ounces (Lapointe and others, 1991).

According to Stager and Tingley (1988), scheelite with little quartz and pyrite is present in several east-trending lenses of chlorite schist surrounded by granite and pegmatite. The largest vertical lens, 100-ft long and maximum 10-ft thick, strikes N70°E. Unfortunately, chlorite schist was not found in the area, perhaps because this tungsten-bearing rock was completely mined out.

Mineralized skarn zones, as much as 4 m wide, dip at angles of 50°-70° to the north or south depending on the attitude of the skarn-controlling contact between bleached Cambrian marble and dikes and sills of Jurassic pegmatitic granite. Granite is commonly gneissic and sheared along the contact. The main skarn zone exposed by an open cut is shown on figures 5*B* and 9. The zone consists of two bands parallel to the contact between white coarse-grained marble and medium-grained gneissic pegmatitic granite. The inner band is composed of exoskarn containing microscopic relicts of granite immediately adjacent to the contact. This skarn consists of a compact primary aggregate of pyroxene, mostly diopside, that is brecciated and cemented by quartz with disseminations and pods of galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, and rare scheelite (see inset "b" on fig. 5*B*). Near quartz-sulfide veinlets, pyroxene is partially replaced by calcite and tremolite. The outer band consists entirely of a retrograde calcite-tremolite assemblage that replaces the adjoining marble. This band also is brecciated and cemented almost entirely by sulfide minerals with little quartz (see inset "a" on fig. 5*B*).

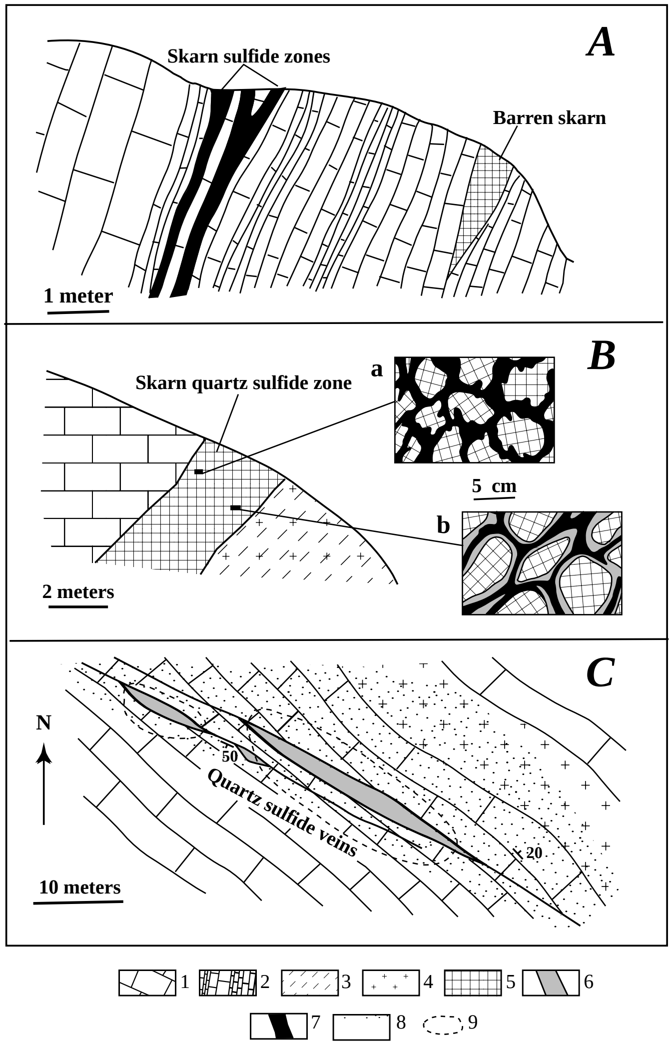


Figure 5 Sketches of polymetallic deposits of the Ruby Mountains: ***A***, Valley View Mine, W-Pb-Zn skarn deposit, wall of the western open cut looking east; ***B***, Battle Creek Mine, W-Pb-Zn skarn deposit, face of the main open cut looking northeast, (a) and (b), details of the ore breccia; ***C***, reconstruction of quartz-sulfide veins on open cut floor in the Knob Hill Mine; 1, thick-bedded marble; 2, thin-layered streaky marble and crystallized limestone; 3, gneissic pegmatitic granite; 4, sill of pegmatitic granite; 5, skarn; 6, quartz with sulfide minerals; 7, veins and pods of sulfides; 8, quartz-sericite alteration; 9, outline

Mineralization in the deposit is divided into four stages: (**1**) pyroxene exoskarn formation; (**2**) shearing and gneissification of granite and brecciation of skarn along the contact; (**3**) overprint of skarn and adjoining marble by a retrograde tremolite-calcite association; and, finally, (**4**) brecciation within the whole skarn zone and precipitation of quartz and sulfide minerals. Clear textural evidence demonstrates some deposition of sulfide minerals after quartz. Within the sulfide assemblage, galena was consistently younger than sphalerite (fig. 10). Eventually, gangue and ore minerals were slightly deformed.

American Beauty Mine

(Lee district, northeastern sideof the Long Canyon)

The American Beauty deposit (fig. 2, loc. 3) is on the western slope of the Ruby Mountains, about 6 kms northwest of the Battle Creek Mine, at an elevation of 8,200 feet (2,460 meters). It was discovered in 1869 with first recorded production in 1871, and then again in 1915–19, 1921–29, 1949–58. Production during the latter period came mainly from the nearby Knob Hill Mine. Total production includes: lead, 1,851,034 lbs; zinc, 123,148 lbs; copper, 24,413 lbs;

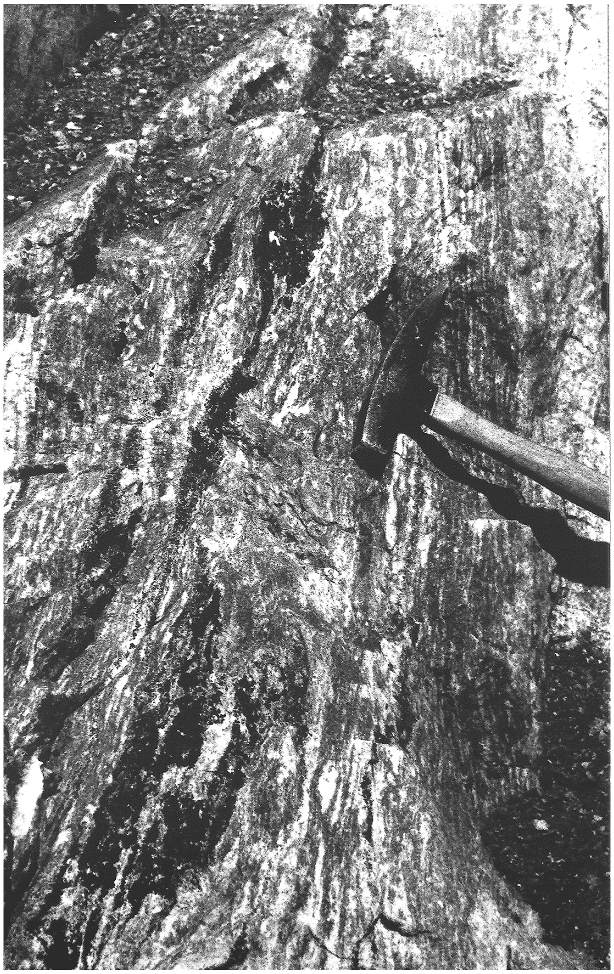


Figure 6 Crystallized streaky limestone containing pyrrhotite dissemination and carbon segregation along bedding planes; exposure nearby portal of the adit in the Valley View Mine.

silver, 11,332 ounces; gold, 56 ounces (Lapointe and others, 1991). Sorted ore during 1949 averaged 29 weight percent Pb and 2 oz Ag/t. The deposit was explored and mined by trenches, cuts, shaft and several east-trending adits.

In many previous descriptions, the deposit was described as “quartz-sulfide veins” present in massive gently east-dipping beds of marble invaded by pegmatitic granite, quartz monzonite, aplite and pegmatite (Lapointe and others, 1991). No vein was exposed in place but, according to Smith (1976), mineralized veins as much as 1.5-m wide strike northwest and dip southwest.

Our observations determined that this deposit originally formed as a typical skarn with intense superposition on the skarn assemblage by retrograde quartz-sulfide ore. Mineralized quartz-sulfide veins are located within an irregularly developed skarn zone in Cambrian marble near a contact with a sill of Jurassic pegmatitic granite; skarn also persists as relicts completely surrounded by quartz.

In dumps from the deposit we found many fragments of skarn associated with quartz-sulfide material. Vitreous light gray to white recrystallized quartz is strongly metamorphosed to foliated mylonite containing rounded fragments of clinopyroxene, idocrase, and celsian from an earlier skarn-mineral assemblage (fig. 11). Quartz contains abundant disseminations, veinlets, and pods of sulfide minerals of two types: early pyrrhotite, chalcopyrite and pyrite; and late galena and sphalerite accompanied by rare tetrahedrite and barite. Galena shows ductile deformation textures (fig. 12). Bentz and Tingley (1983) noted late-stage quartz-pyrite veinlets in some samples of crudely banded quartz-sulfide veins.

The presence of celsian, a barium plagioclase feldspar, in a skarn assemblage is a particular feature of this deposit. We have checked numerous published sources and did not find any references to celsian in various well-described skarn deposits. This extraordinary fact attracted our attention and the celsian was studied in somewhat more detail. Celsian is represented by rounded fragments up to 0.3 mm in diameter within metamorphosed quartz. It is very abundant in some places, representing as much as 3 volume percent of the gangue mass. The mineral was identified and analyzed by Scanning Electron Microprobe (fig. 13*A*, table 1) and then compared with known mineralogical and analytical data (Deer and others, 1965). According to published mineralogical descriptions, celsian commonly is present as well-formed tabular crystals. In our case, however, the rounded fragments of celsian indicate that it underwent mylonitization along with pyroxene and other skarn minerals. In the same samples, fragments of pyroxene were found with fine barite and galena inclusions that exhibit a late barite-sulfide association (fig. 13*A-B*).

Three important features are emphasized about the deposit: (**1**) originally skarn-type, the deposit currently is represented mainly by superposed retrograde quartz-sulfide assemblages containing only relicts of skarn minerals including celsian; (**2**) the deposit contains no tungsten mineralization; (**3**) strong metamorphism and polyphase mylonitization of ore (pre- and post- quartz-sulfide mylonitization) are related to an offshoot of the regional “transition” mylonitic zone.

Knob Hill Mine

(Lee district, southwestern side of the Long Canyon)

The Knob Hill deposit (fig. 2, loc. 4) is located at elevation of 8,700 feet (2,610 meters) on the southwestern slope of the Long Canyon opposite the American Beauty Mine, by about 1 kilometer. Several open cuts were made in the vicinity of old underground workings, most likely during the1970’s.

Quartz-sulfide veins striking N40°W and dipping 50° SW and their surrounding geology have been reconstructed on a sketch of the upper open cut from fragments on the floor and small exposures on collapsed flanking walls (fig. 5*C*). Veins

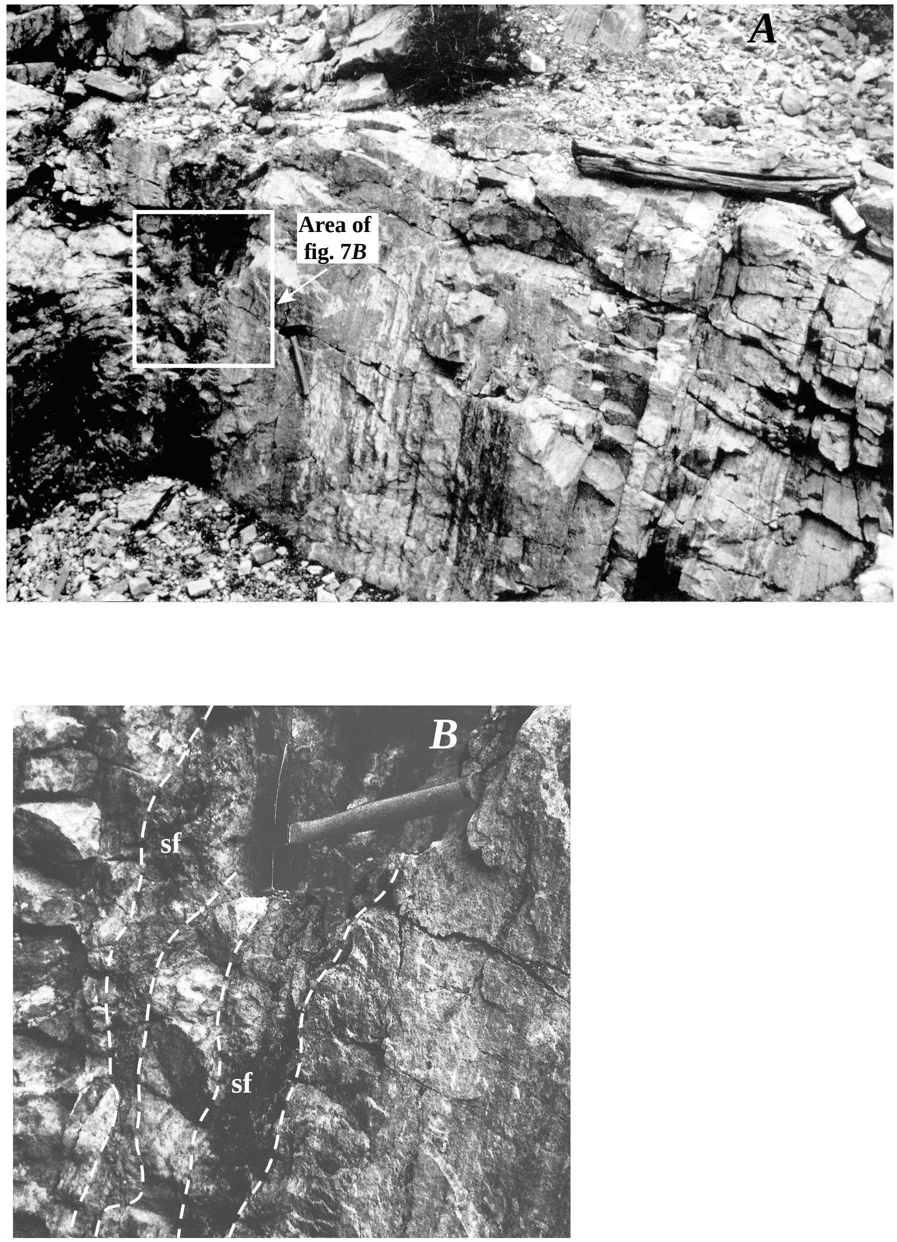


Figure 7 ***A***, Stratabound skarn sulfide zones exposed on wall of the western open cut in the Valley View Mine, looking east. ***B***, Photograph of area outline in A; sf, sulfide zone.

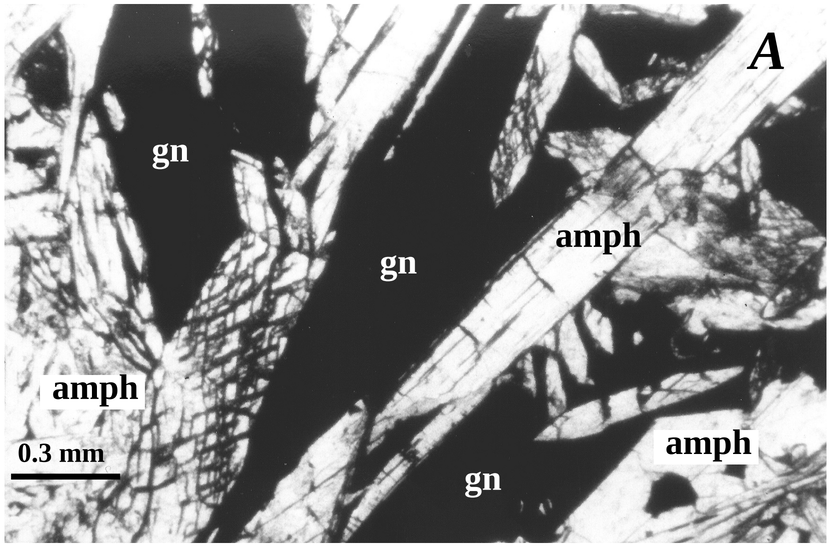
cut crystallized Cambrian limestone gently dipping to N20°E close to the pegmatitic granite sill. Both rock types are bleached, recrystallized, silicified, and cut by irregular thin quartz-calcite veinlets. The veins are composed of sugar-like quartz containing disseminations and pods of galena, sphalerite, and pyrite. All veins are deformed and recrystallized by strong metamorphism and mylonitization. Slickensides are traced on vein walls.

In this deposit located at a high elevation, no evidence of skarn was found around the quartz-sulfide veins or along the contact between limestone and pegmatitic granite. Instead, hydrothermal silicification and veining by carbonate minerals are present. The deposit probably represents a “pure” end-member quartz-polymetallic vein type well known within skarn districts (Cox and Singer, 1986).

Summit View Mine

(Corral Creek district)

The Summit View deposit (fig. 2, loc. 5) is on the south side of the Corral Creek valley, on the west slope of the Ruby



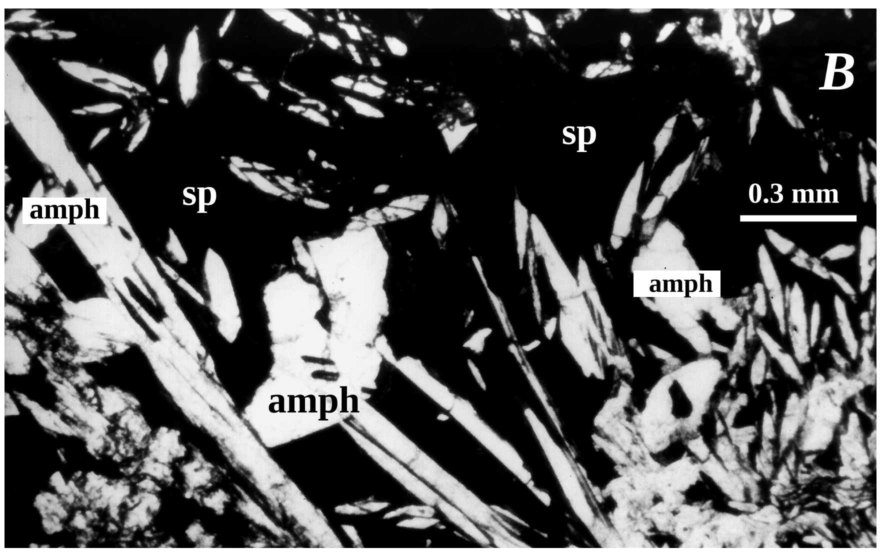


Figure 8 Photomicrographs of skarn sulfide ore from the Valley View Mine. Pods of (***A***) galena (gn) and (***B***) sphalerite (sp), partially replaced by late amphibole (amph).

Mountains, and southwest of Harrison Pass. The first known record of activity in the area was in 1925. Roughly 108 tons of sulfide ore that averaged 2.5 weight percent lead, 1.1 weight percent zinc, 0.15 weight percent copper, and 3.0 oz Ag/t were mined during 1948–1952. Three south-trending adits and relatively recent bulldozing are mentioned in the latest deposit description (Lapointe and others, 1991).

About 12 tons of tungsten ore averaged 0.6 weight percent WO_3 was mined from S. & L. Mother No 1 claim in 1979. This locality is about 3 km northeast of the Summit View Mine. A contact skarn zone between Cambrian limestone and Tertiary Harrison Pass granitic pluton dips steeply at 70° to the northwest. Fine-grained laminated scheelite-bearing skarn consists of amphibole-garnet-epidote assemblages.

In the eastern part of the Summit View Mine, a quartz-sulfide vein was traced along the contact skarn zone between marble and leucocratic granite of the Harrison Pass pluton. A nearly horizontal mineralized zone 1-m thick is present. Disseminations and pods of galena, sphalerite, pyrite, chalcopyrite, and pyrrhotite are distributed in quartz with minor calcite. Quartz is distinguished by an original mosaic to crustified texture without any traces of metamorphism (fig.

Figure 9 Battle Creek Mine; face of the main open cut looking northeast; 1, Marble; 2, tremolite-actinolite skarn with sulfide minerals; 3, brecciated pyroxene skarn with quartz-sulfide veins; 4, gneissic pegmatitic granite.

14*A*). It contains fragments of garnet and amphibole from an older skarn assemblage. Sulfide minerals, representing mostly the latest portion of the mineralizing event, fill open spaces in quartz in association with well-shaped tabular crystals of celsian and aggregates of apatite, both as much as 0.2 mm wide (fig. 14*B-C*).

Grains of celsian are partially replaced with hyalophane (fig. 14*D*). Chemical compositions of the celsian, shown in the table 1, is nearly standard and close to samples from the American Beauty Mine. The principal difference is that celsian from that deposit is from a compound skarn assemblage that pre-dated quartz and sulfide minerals. In the Summit View Mine, celsian with sulfide minerals post-dates crystallization of quartz. Further study is needed to explain this difference.

BARITE DEPOSITS

During the 1997 field season, barite deposits of the Judy Mine, B & P claims, and Dorsey Canyon prospect, which are hosted by non-metamorphosed miogeoclinal sedimentary rocks, were also examined. The purpose of this investigation was to compare this barite mineralization with barite showings along the Carlin trend and around it. Data about the above listed barite deposits were gathered by Papke (1984), Bentz and Tingley (1983), Lapointe and others (1981), and Smith (1976).

Judy Mine
(Cave Creek district)

The deposit at the Judy Mine (fig. 2, loc. 6) is situated in southern part of the Ruby Mountains, immediately north of Elko-White Pine County line. Two claims were located in 1972; total past production was between 1,000 and 25,000 tons of barite from a 120–m-long open cut trending N25°E. The deposit area also was explored by shallow pits and drilling.

According to Papke (1984), a roughly stratiform zone of vein-replacement-type barite mineralization, 25 m of estimated stratigraphic thickness, is hosted by dark gray bituminous Devonian dolomite gently dipping southward at about 20°, and seldom exceeding 40°. At the south end of the area, mineralized dolomite is in steep fault contact with north-dipping, fossiliferous limestone. Downslope to the east, dolomite is underlain by sandstone.

During our visit to the deposit, the southern face of the open cut, about 9-m high, was partially accessible for detailed observations. High-grade stratiform barite >5 m thick is exposed in the lower part of the face. The lode consists of two bands with irregular outlines (fig. 15*A*). A footwall band 2–3 m thick is composed of gray massive bedded barite that follows the dolomite bedding. The upper band of the lode is made up of conformable barite-calcite-dolomite breccia superposed on an earlier massive bedded barite.

An east-west-striking high-angle (dipping 70° N) normal fault branches downward and terminates the massive barite ledge within the open cut. The massive barite reappears again at the north end of the open cut. The lode of similar "two-band" structure can be traced there, and is offset by a high-angle fault. Sparse coalescing calcite-barite veins as much as 5 cm thick and fragments of barite-calcite breccia with locally leached sandy dolomite are exposed within the central part of the open cut between the two ends of the pit.

Massive barite from the footwall ledge shows several particular features:

- it is fine- to medium-grained, slightly but clearly deformed and recrystallized;

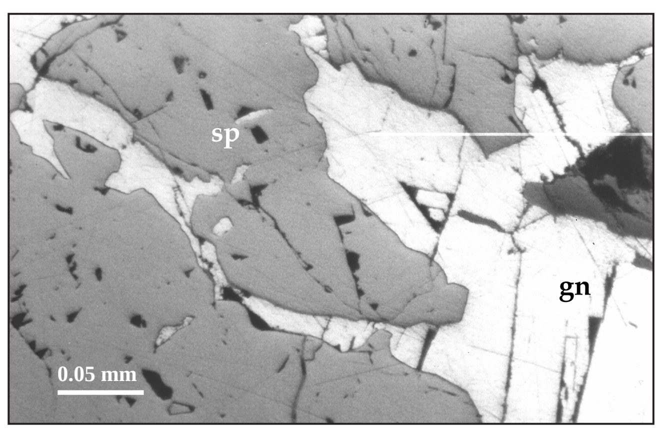


Figure 10 Photograph of galena (gn) in relation to sphalerite (sp) in quartz-sulfide vein in skarn zone of the Battle Creek Mine, reflected light.

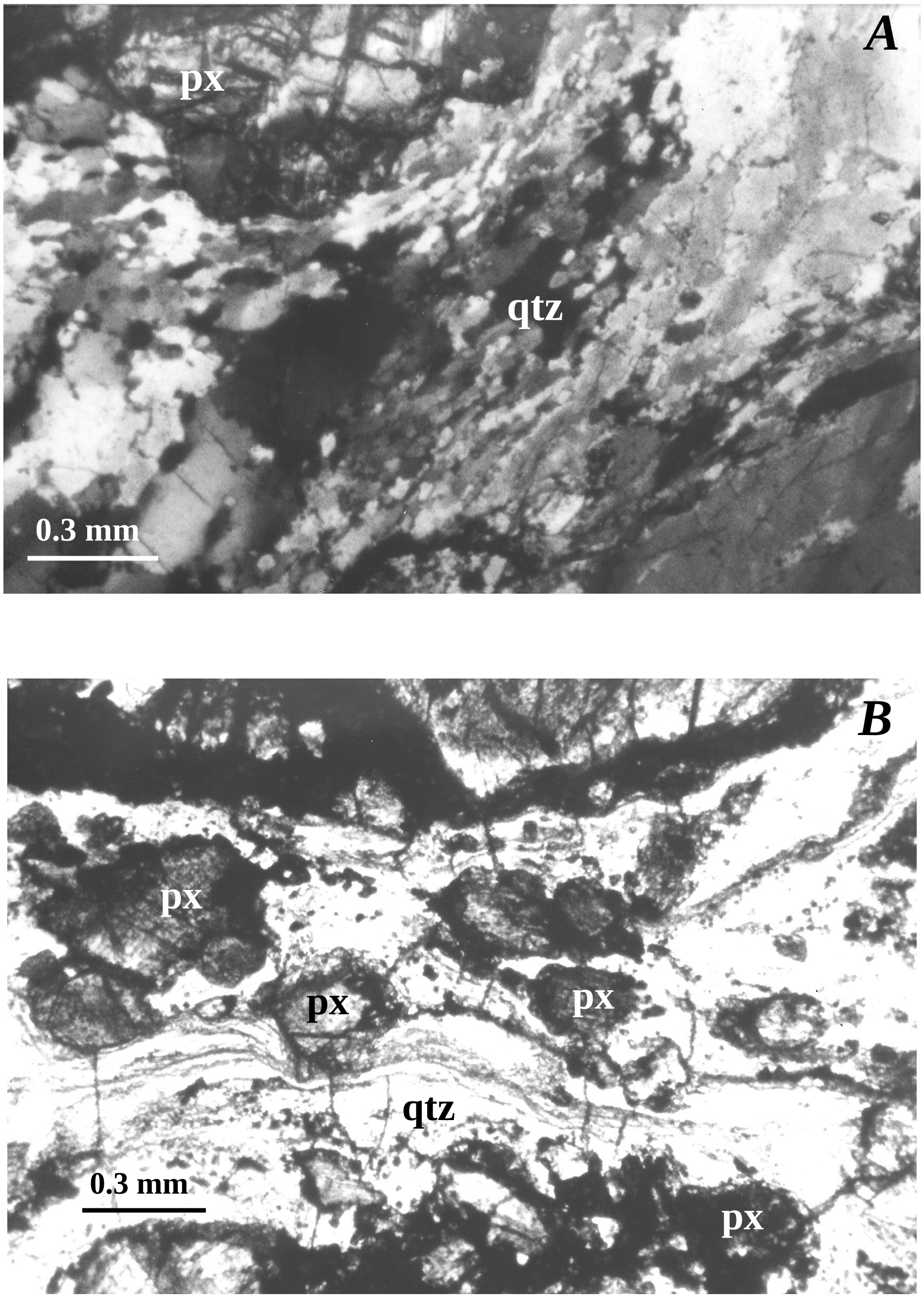
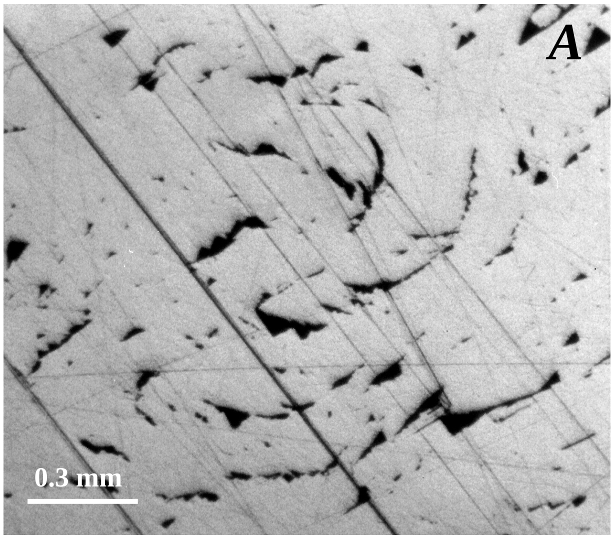


Figure 11 Photomicrographs of samples from quartz-skarn zone of the American Beauty Mine: ***A***, cataclastic metamorphosed quartz (qtz) with fragment of pyroxene (px), crossed nicols; ***B***, laminated mylonitic quartz containing rounded fragments of pyroxene, plane-polarized light.

- it contains relicts of original thin-lamination marked partially by bitumen inclusions along bedding planes (fig. 16*A*); the lamination are bent and rotated along microfaults that separate barite domains;
- it is partly replaced by newly grown rhomboids of calcite and dolomite (fig. 16*B*) accompanied by intergranular spheroid micropore resulting from barite dissolution;
- it is fetid when broken, which derives probably from unsealing of the micropores and H_2S–gas release during crushing.

The footwall stratiform ledge of early deformed massive barite obviously is of bedded barite-type. Such classification is supported by analogy to bedded barite deposits widespread throughout Nevada and well known in various stratigraphic



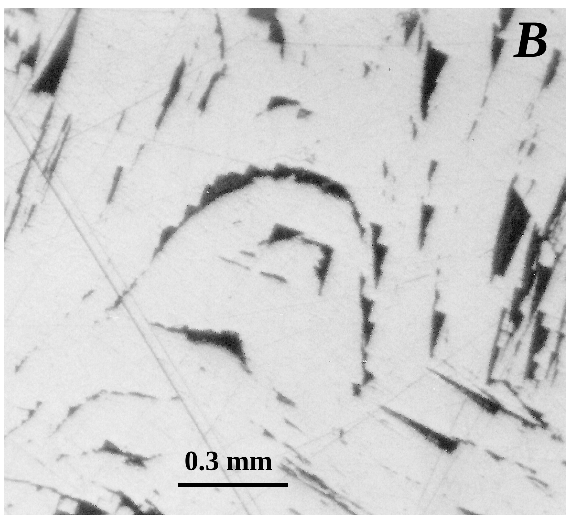


Figure 12 Photomicrographs of deformed galena in metamorphosed ore from the American Beauty Mine and Knob Hill Mine, reflected light: S-like (***A***) and dome-like (***B***) curved cleavage pits as a result of deformation.

units within Elko county (Zimmerman, 1969; Poole, 1975; Papke, 1984), including a Mississippian mudstone-chert sequence identified by conodonts in a bedded barite locality in the Snake Mountains (Poole and others, 1982).

The superposed barite-calcite-dolomite breccia comformably overlays bedded barite and include part of its upper part (fig. 15*A-B*). The breccia contains fragments of layers and angular blocks of dolomite-cemented bedded barite; these clasts are partially replaced by barite and calcite. White sugary veins of barite and calcite extend along bedding planes and cut dolomite outside the breccia. The late barite is radically different from the earlier massive one. It is white and glassy, consisting of crustified and micro-drusy aggregates of tabular crystals without any signs of deformation (fig. 16*C*). It seems possible that this late barite is a product of late post-deformation, probably extensional, hydrothermal remobilization of older bedded barite that underwent partial dissolution and replacement by carbonate minerals during brecciation.

B & P Claims
(Cave Creek district)

The B & P claims (fig. 2, loc. 7) were first located in 1972 as a barite prospect in the Mitchell Creek drainage area, 4 km northwest of the Judy Mine. The prospect was explored by trenches and drilling focused on an area of about 300 square meters. Papke (1984) described two barite-bearing zones exposed in a northeastward-trending face and separated by about 6 m of nearly barren dolomite.

Exposures of the main zone were in relatively good condition during our visit to the prospect. Barite-calcite breccia is present within a veined and fractured zone, as much as 5 m wide, striking N35-45°W and dipping 50-80° NE. The zone cuts medium- to dark-gray fine-grained Devonian dolomite. Nearby bedded fossiliferous limestone and dolomite striking north-south and dip 35° W.

An axial lens of pure barite, about 1 m thick and 6 m long, occupies the central part of the breccia zone. The barite lens is bordered by semiparallel shears zones. Sparse short barite and calcite veinlets and pods 5–10 cm thick are present along a 15-m strike length of the exposed zone. Calcite and minor quartz are also present in the zone. White sugary fine-grained barite is widespread. Glassy crystalline barite found in the main axial zone consists of microscopic aggregates of undeformed tabular crystals, similar to those in the breccia and veins of the Judy Mine.

Dorsey Canyon Prospect
(Halleck district)

The Dorsey Canyon prospect (fig. 2, loc. 8) is located in the Secret Creek area within a low-angle fault sheet described by Snoke (1980) as a detachment slice of low-grade metasedimentary rocks structurally overlying the lower plate metamorphic complex. The mineralized zone at the prospect is exposed in several shallow pits. Calcite and quartz veinlets and local calcite-barite breccia cut bleached and silicified Permian limestone, striking N70°W, along a steep fault contact between limestone and siliceous conglomerate, striking N40°W. The angular mineralized breccia is obviously young.

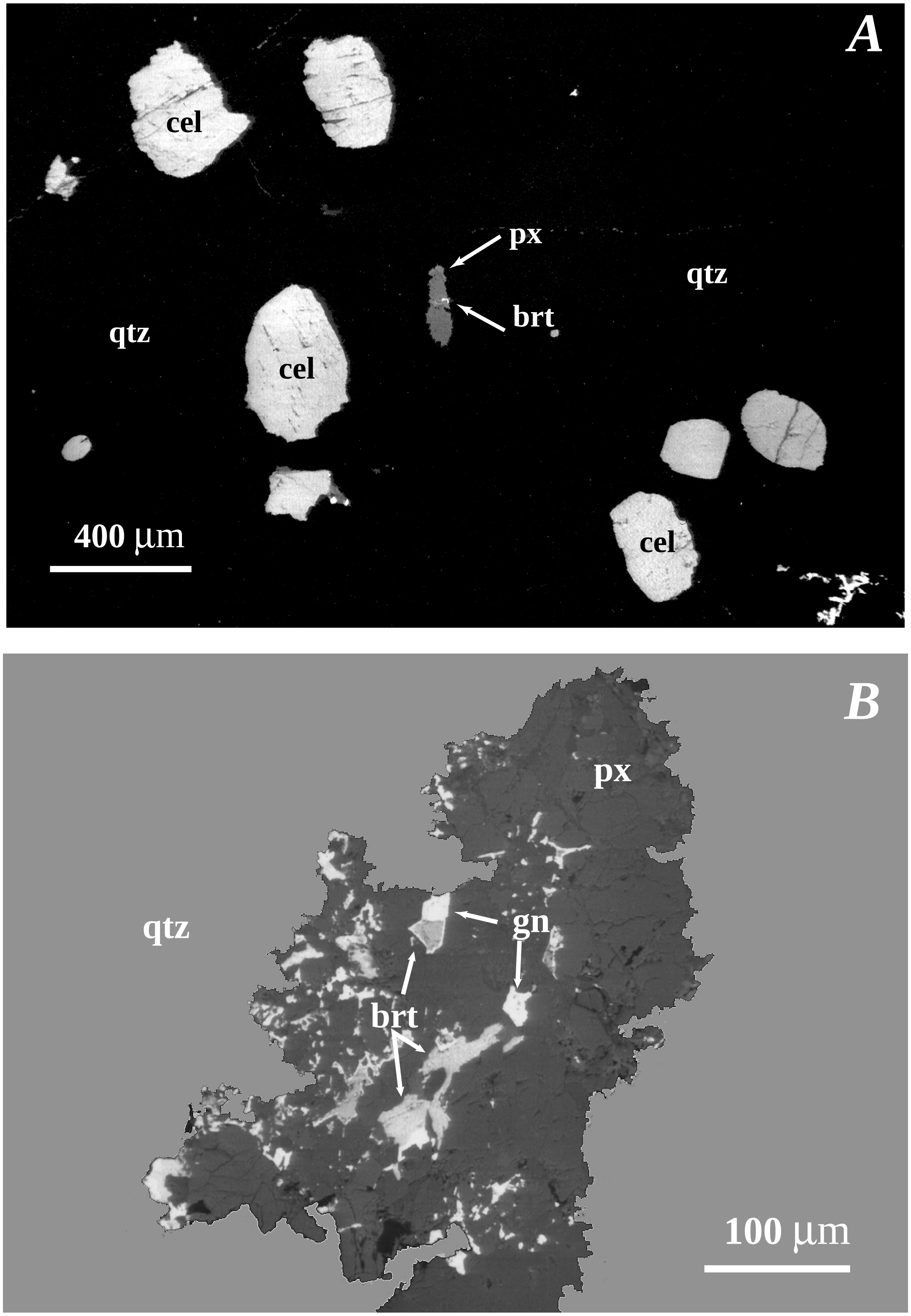


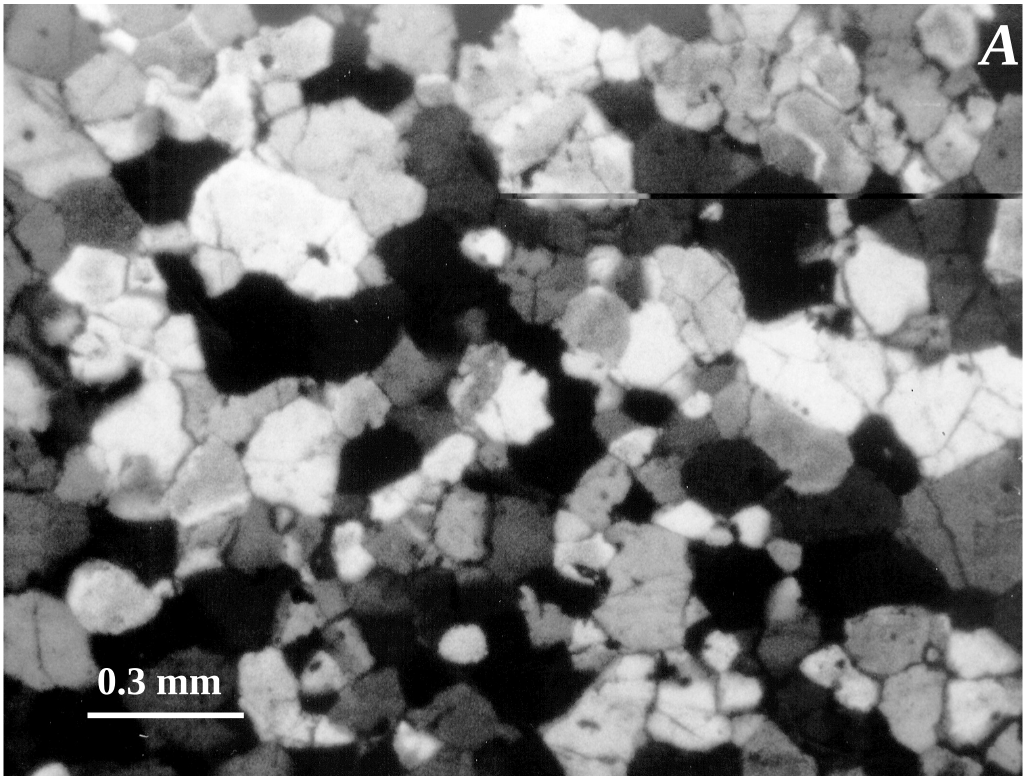
Figure 13 Back-scattered electron image (BSE) of ore from quartz skarn zone of the American Beauty Mine: ***A***, rounded fragments of celsian (cel) in ore-host quartz (qtz) containing also single grain of pyroxene (px) with barite (brt) inclusion; ***B***, fragment of pyroxene, surrounded by quartz, containing barite and galena (gn).

Table 1 Electron-microprobe analyses of celsian

No.	Deposit and sample No.	SiO_2	Al_2O_3	BaO	K_2O	Na_2O	Total
	American Beauty Mine						
1	Sample B97-1	34.44	27.84	38.92	0.39	0.15	101.73
2		34.04	28.02	39.57	0.35	0.16	102.14
3		34.07	28.23	39.58	0.34	0.13	102.34
4		33.96	28.02	40.29	0.20	0.15	102.61
5		34.04	28.25	39.37	0.27	0.14	102.07
6		34.64	28.28	39.37	0.46	0.16	102.92
7		34.16	28.32	39.32	0.29	0.15	102.24
8		34.17	27.95	39.25	0.38	0.13	101.89
9		34.07	28.08	39.83	0.34	0.20	102.52
10		34.17	27.92	38.89	0.41	0.13	101.52
	Average	34.17	28.09	39.44	0.34	0.15	102.20
11	Sample B97-1B	33.02	28.62	40.03	0.19	0.09	101.94
12		33.48	28.13	39.78	0.43	0.12	101.93
13		33.6	27.74	39.27	0.38	0.13	101.13
14		33.82	28.26	39.69	0.21	0.12	102.11
15		33.84	28.53	39.95	0.31	0.10	102.74
16		34.45	28.54	40.04	0.37	0.12	103.53
17		34.31	25.03	39.97	0.43	0.13	99.87
18		34.02	28.27	39.33	0.37	0.10	102.08
	Average	33.82	27.89	39.76	0.34	0.11	101.92
	Summit View Mine						
19	Sample B97-42E	34.11	28.07	38.54	0.7	0.09	101.50
20		34.71	28.35	37.97	0.88	0.13	102.05
21		36.82	27.11	35.59	1.74	0.17	101.43
22		35.35	28.04	37.99	1.20	0.11	102.70
23		35.42	27.52	36.44	1.24	0.15	100.77
	Average	35.28	27.82	37.31	1.15	0.13	101.69
24	Sample B97-42B	35.04	27.96	37.56	0.69	0.20	101.45
25		35.82	27.90	36.82	1.07	0.23	101.85
26		35.88	28.08	37.11	1.10	0.25	102.42
27		34.97	28.13	39.28	0.72	0.24	103.34
28		36.53	28.00	38.02	0.89	0.20	103.63
29		37.6	27.25	35.89	1.55	0.29	102.58
30		36.68	27.97	36.61	1.34	0.30	102.90
31		34.89	26.63	36.06	0.95	0.27	98.80
32		47.85	24.45	31.20	2.52	0.41	106.43
33		36.22	24.77	36.37	1.12	0.22	98.71
34		35.66	27.71	37.47	0.97	0.21	102.02
35		34.18	28.28	39.48	0.35	0.11	102.39
36		43.41	24.22	34.32	0.73	0.17	102.84
37		36.81	27.78	37.02	1.43	0.30	103.34
38		38.36	27.20	37.44	0.65	0.18	103.83
39		42.98	25.03	34.55	0.71	0.21	103.47
40		35.52	28.25	38.11	0.81	0.26	102.95
41		44.87	24.77	34.62	0.88	0.21	105.35
	Average	37.96	26.91	36.55	1.03	0.24	102.68

Table 1 continued. Atomic proportion

No	Deposit and sample No	Si	Al	Ba	K	Na	Total
	American Beauty Mine						
1	Sample B97-1	8.23	7.84	3.64	0.12	0.07	19.90
2		8.15	7.91	3.71	0.11	0.07	19.95
3		8.14	7.95	3.71	0.10	0.06	19.96
4		8.14	7.91	3.78	0.06	0.07	19.96
5		8.14	7.96	3.69	0.08	0.07	19.94
6		8.19	7.88	3.65	0.14	0.07	19.93
7		8.14	7.95	3.67	0.09	0.07	19.92
8		8.18	7.89	3.68	0.12	0.06	19.93
9		8.14	7.91	3.73	0.10	0.09	19.97
10		8.19	7.89	3.66	0.12	0.06	19.92
	Average	8.16	7.91	3.69	0.10	0.07	19.94
11	B97 -1B	7.96	8.14	3.78	0.06	0.04	19.98
12		8.07	7.99	3.75	0.13	0.05	19.99
13		8.04	7.82	3.68	0.12	0.06	19.72
14		8.10	7.98	3.73	0.06	0.06	19.93
15		8.07	8.02	3.73	0.09	0.05	19.96
16		8.13	7.94	3.70	0.11	0.06	19.94
17		8.50	7.31	3.88	0.14	0.06	19.89
18		8.13	7.97	3.69	0.11	0.05	19.95
	Average	8.13	7.90	3.74	0.10	0.05	19.92
	Summit View Mine						
19	Sample B97-42E	8.15	7.90	3.61	0.21	0.04	19.91
20		8.21	7.90	3.52	0.27	0.06	19.96
21		8.61	7.47	3.26	0.52	0.07	19.93
22		8.30	7.76	3.50	0.36	0.05	19.97
23		8.40	7.69	3.39	0.38	0.07	19.93
	Average	8.33	7.74	3.46	0.35	0.06	19.94
	Summit View Mine						
24	Sample B97-42B	8.31	7.81	3.49	0.21	0.09	19.91
25		8.40	7.72	3.39	0.32	0.11	19.94
26		8.38	7.73	3.40	0.33	0.11	19.95
27		8.23	7.81	3.62	0.22	0.11	19.99
28		8.45	7.64	3.45	0.26	0.09	19.89
29		8.67	7.41	3.24	0.46	0.13	19.91
30		8.48	7.62	3.32	0.40	0.13	19.95
31		8.44	7.59	3.42	0.29	0.13	19.87
32		9.99	6.02	2.55	0.67	0.17	19.40
33		8.81	7.10	3.47	0.35	0.10	19.83
34		8.39	7.69	3.46	0.29	0.10	19.93
35		8.14	7.94	3.69	0.11	0.05	19.93
36		9.65	6.35	2.99	0.21	0.07	19.27
37		8.50	7.56	3.35	0.42	0.13	19.96
38		8.76	7.32	3.35	0.19	0.08	19.70
39		9.52	6.53	3.00	0.20	0.09	19.34
40		8.31	7.79	3.49	0.24	0.12	19.95
41		9.70	6.31	2.93	0.24	0.09	19.27
	Average	8.67	7.39	3.33	0.30	0.11	19.81



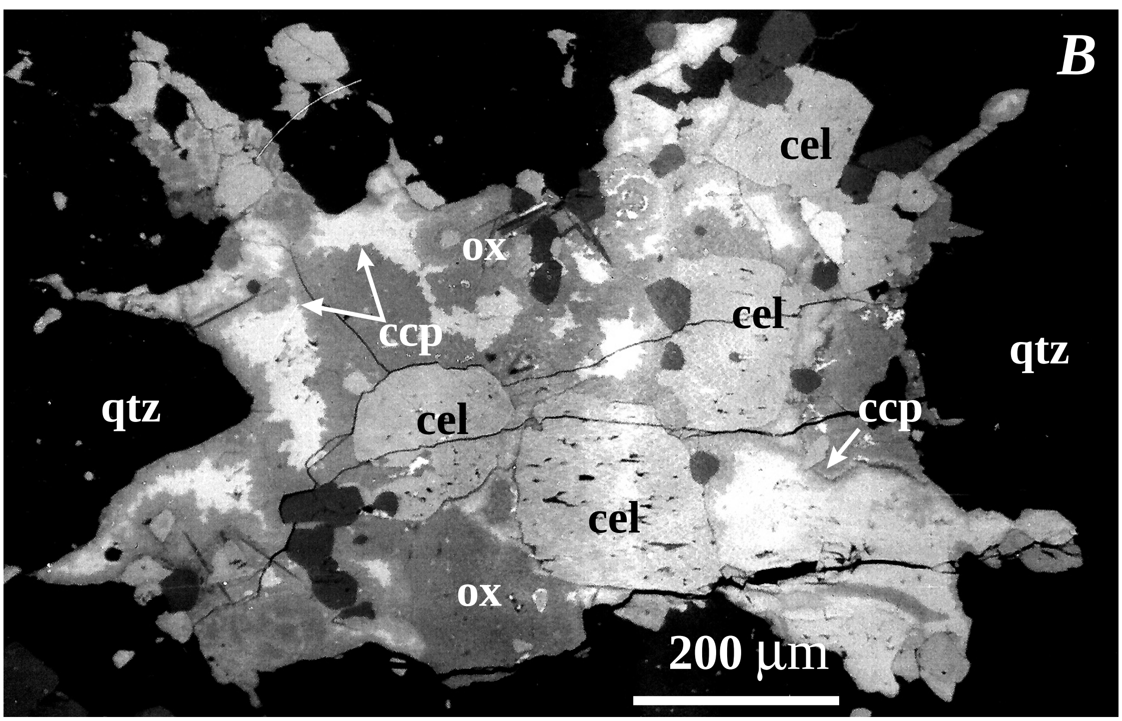
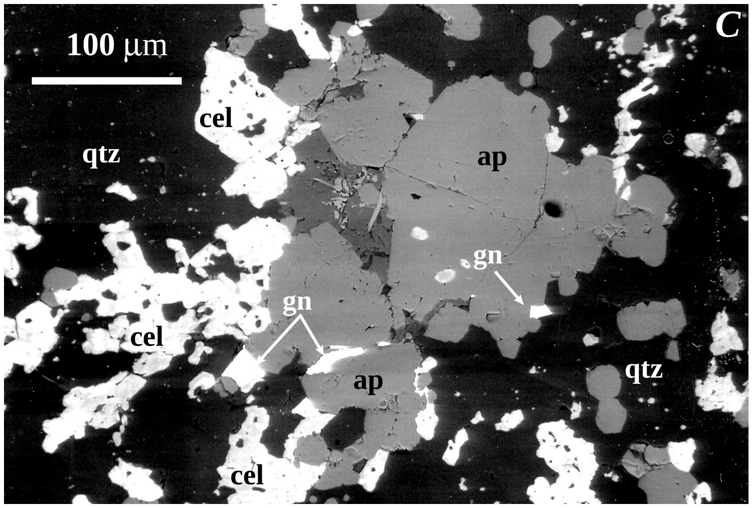


Figure 14 Photomicrograph and back-scattered electron images of samples from quartz skarn sulfide zone of the Summit View Mine. ***A***, Photomicrograph of original mosaic texture of ore-host quartz, crossed nicols; BSE images; ***B***, aggregate of celsian crystals (cel) with chalcopyrite (ccp) and Cu, Fe-oxides (ox) filling open space in quartz (qtz); ***C*** and ***D*** continued on next page.



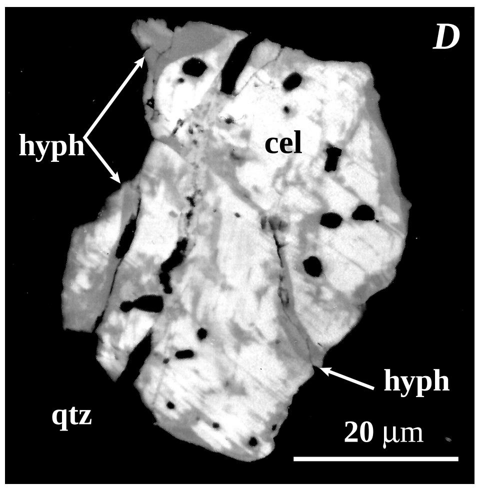


Figure 14 continued: ***C***, aggregate of apatite (ap), celsian and galena (gn) filling open space in quartz; ***D***, grain of celsian partially replaced (?) by hyalophane (hyph).

DISCUSSION AND CONCLUSIONS

Principal features of the mineral deposits and their geologic setting are shown on figure 17. Table 2 summarizes the general geologic and metallogenic succession within the Ruby Mountains.

Data obtained during this investigation allow us to conclude the following:

(**1**) At least two phases of skarn formation are evidenced in the Ruby Mountains: the first skarn phase is related to Late Jurassic magmatism and second to Oligocene granite-monzonite of the Harrison Pass pluton. Skarn deposits of both phases are present at the same stratigraphic level, which is the Cambrian marble and limestone. They also contain mineralized rocks of very similar W + Pb, Zn, Cu, Ag, and Ba composition. The main difference includes the various compositions of the skarn-mineral assemblages themselves: first, pyroxene-idocrase with minor garnet and retrograde association of amphibole (actinolite-tremolite)-epidote-calcite accompanied by quartz-sulfide minerals; second, amphibole-epidote-garnet skarn assemblage with a calcite-quartz retrograde association. This difference and the varied ore textures, almost “epithermal” in the second case, probably result from different depths of the intrusion emplacement—deep Jurassic pegmatitic granite and shallow Tertiary pluton—and related differences in pressure and temperature during skarn formation. Einaudi and others (1981) and Meinert (1993)

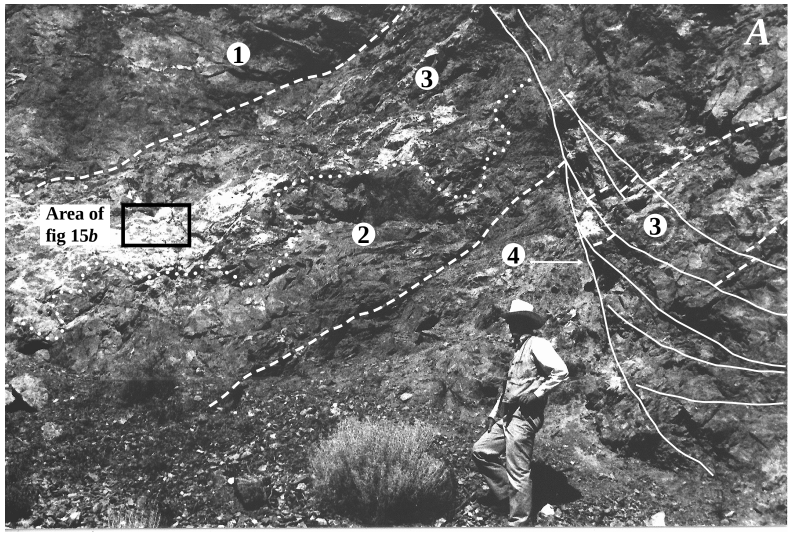
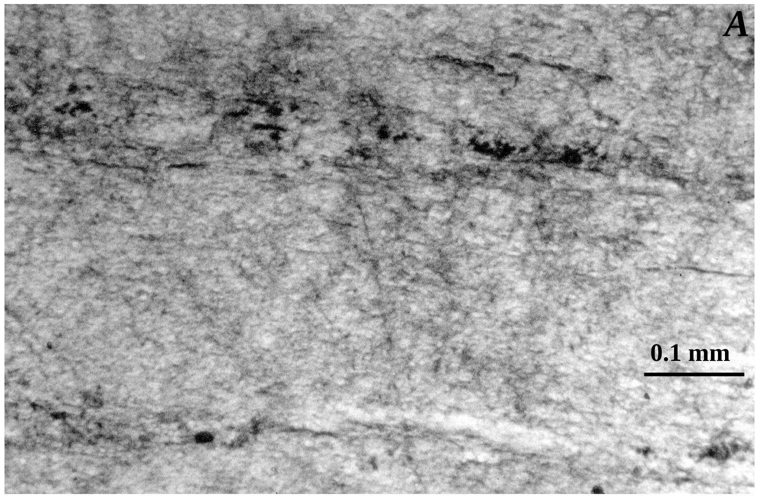


Figure 15 Face of the main open cut of the Judy barite mine looking northwest; ***A***, Photograph of stratiform barite zone: 1, Devonian dolomite; 2, early bedded barite; 3, late barite-calcite-dolomite breccia; 4, post-mineral fault. ***B***, Photograph of area outlined in A showing structure of the late breccia.

point out the importance of such depth factors during skarn genesis.

(**2**) Combined vertical zoning of skarn mineralization can be established for nearby deposits at the Battle Creek Mine (2,220 m elevation), American Beauty Mine (2,460 m) and Knob Hill Mine (2,610 m) which are present in the same area of a roof pendant of the Jurassic pegmatitic granite. At the lower elevations, tungsten and quartz-polymetallic mineralization is hosted by a well-developed skarn zone. Approximately 240 m higher, polymetallic sulfide mineralization without tungsten is hosted by quartz containing only fragments of skarn, that was almost completely destroyed during retrograde processes. About 150 m higher at the uppermost level of the hydrothermal system, only quartz-polymetallic veins are present and surrounded by a hydrothermal halo of silicification and carbonate veinlets. No significant gold appears anywhere within this vertical zoning. Quartz-sulfide veins are located, as a rule, within skarn zones and rarely as individual occurrences in the upper part of the vertical zonation. They certainly are related to retrograde stages of skarn formation that had been initiated by granite intrusions. In places, the quartz-sulfide veins have been deformed cataclastically. The quartz-sulfide veins are post-regional metamorphism and late- or post-granitic and cannot be considered as an analog of low-sulfide gold- quartz vein type.

(**3**) Celsian (barium feldspar), discovered in skarn deposits of



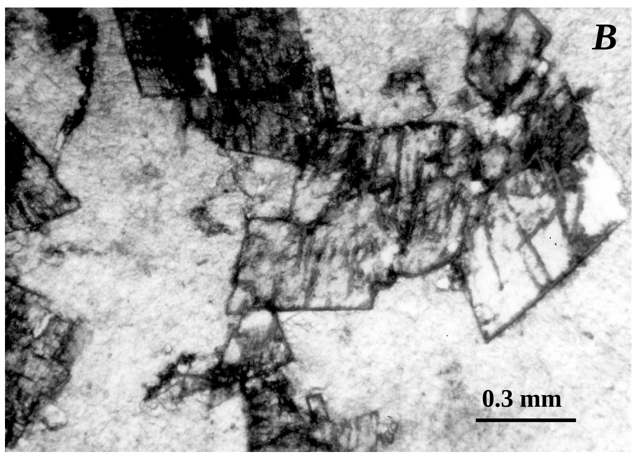


Figure 16 Photomicrographs of various types of barite from the Judy Mine, Nevada. ***A***, early gray barite with parallel traces of probable original lamination, plane-polarized light; ***B***, replacement of early barite by calcite rhomboids, plane-polarized light. (Figure ***C*** on the next page.)

the Ruby Mountains, is not reported as a component of skarn-mineral assemblages (Einaudi and others, 1981; Meinert, 1993; Singer and others, 1997). Theodore and Roberts (1971) first describe it from Nevada in deep drill holes at Iron Canyon in metamorphosed and altered chert, argillite and greenstone of the Devonian Scott Canyon Formation. Celsian was accompanied there by sphalerite. In many other cases, celsian was explained invariably as a result of metamorphism, commonly contact metamorphism, of barite-bearing VMS and SEDEX polymetallic deposits, and magnesium deposits (Segnite, 1946; Deer and others, 1965; Coats and others, 1980; Yudovskaya and others, 1997). In the Ruby Mountains, celsian is represented in ores of both major phases of skarn formation. Its appearance in a contact-metamorphic paragenesis needs to be studied further. However, we can only speculate that the ore-host Cambrian carbonate rocks might have contained pre-metamorphic barite-bearing SEDEX mineralization (table 2). Unfortunately, we did not find any evidence of this precursor mineralization except for possibly the pyrrhotite disseminations in crystallized limestone at the Valley View Mine. An alternative possibility is to consider celsian as a granite-generated component of the skarn-polymetallic-barite assemblage.

(**4**) Skarn mineralization is not related commonly to Carlin-type gold deposits. But there is a case history at the Getchell deposit in the Osgood Mountains, Nevada, where granodiorite intrusion and associated tungsten skarns are located close to

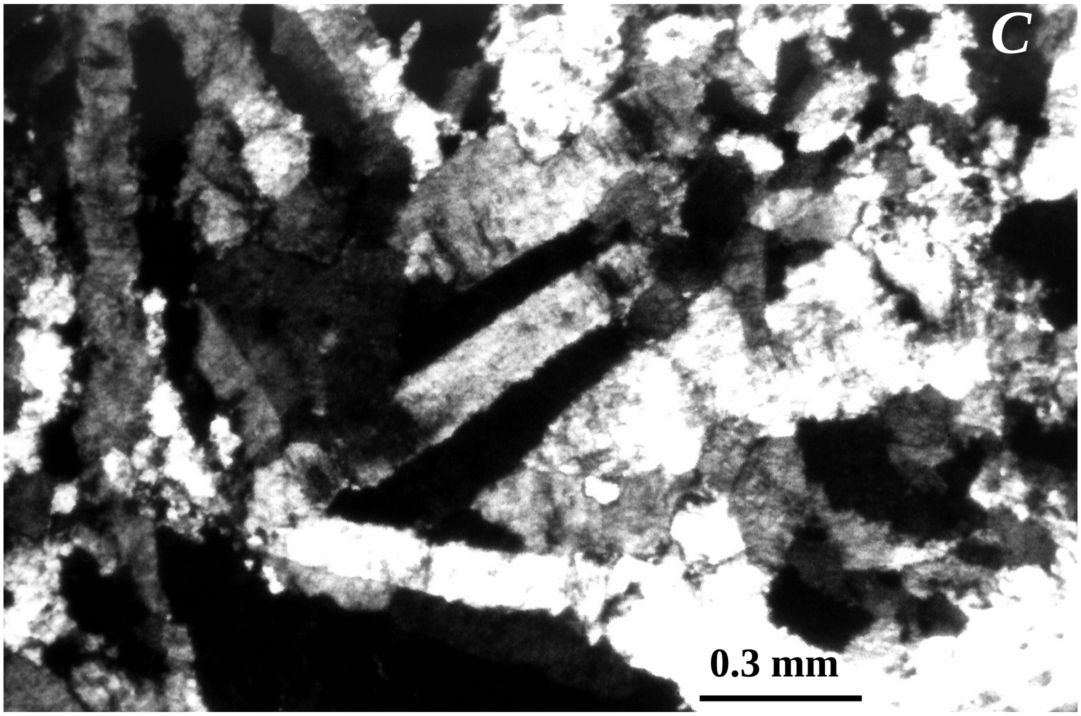


Figure 16 continued: ***C***, aggregate of tabular crystals of late barite from veinlets, crossed nicols.

Carlin-type mineralization. Opposing opinions about their age and genetic ties have been discussed (Joralemon, 1975; Silberman and others, 1974). But true relationships of these two events are not clear still (Bagby and Cline, 1991), although many geologists believe the Carlin-type deposits at Getchell are much younger than the tungsten skarn (Groff and others, 1997). Gold is not a documented significant component of skarn mineralization in the Ruby Mountains. Furthermore, the existence of a complete combined vertical zoning of the skarn deposits probably does not allow space for any "skarn roots" of Carlin-type gold mineralization in the migmatitic core complex of this region.

(**5**) Bedded barite in Devonian dolomite of the southern Ruby Mountains could be roughly compared with the newly discovered barite-bearing SEDEX-type base- and precious-metal mineralized rocks of the northern Carlin trend (Emsbo and others, 1997). However, an absence of metallic associates in bedded barite of the Judy Mine places strong constraints upon such a comparison. Barite is an insignificant but common component of many Carlin-type deposits. But the same reasoning constrains comparisons of vein barite occurrences of the Ruby Mountains with Carlin-type deposits in the Alligator Ridge and Yankee Mine to the south of the Ruby Mountains (fig. 1). Those deposits are located in Mississippian strata (Ilchik, 1991; Stout, 1997).

This study in the Ruby Mountains did not reveal any "roots", connections, or analogs for Carlin-type gold deposits. However, the investigation necessarily was of a short duration and should not be considered comprehensive.

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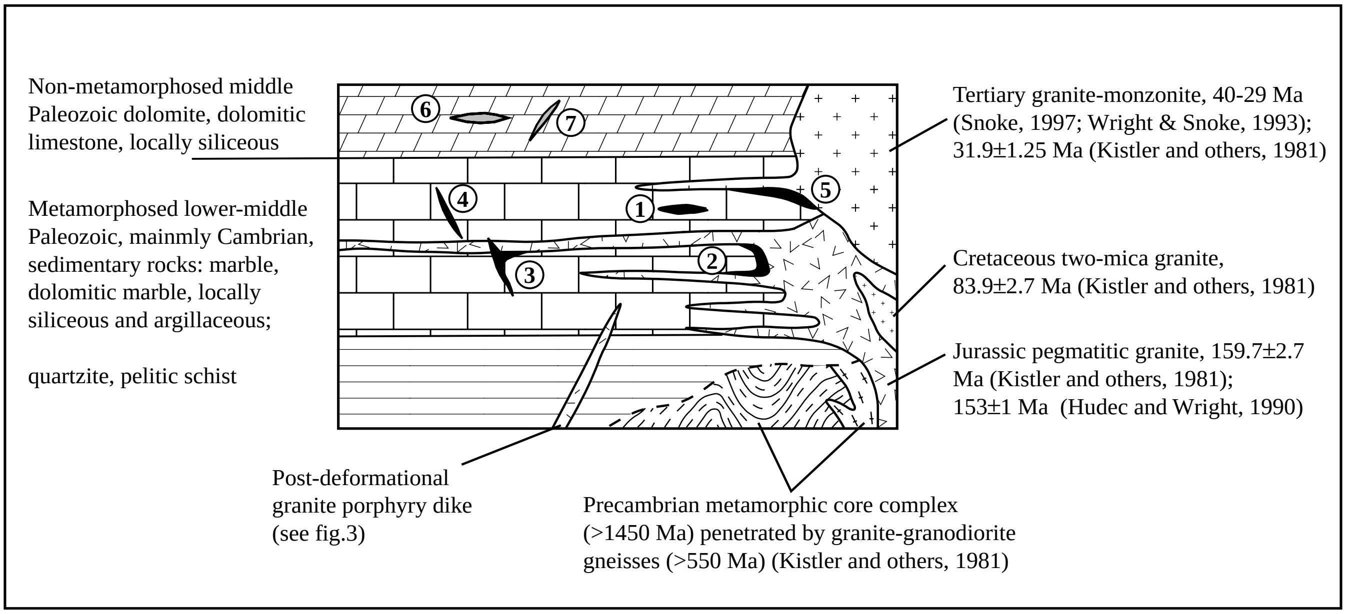

Figure 17. Mineral deposits in the Ruby Mountains, Nevada, shown in a schematic geologic setting simplified from Howard, 1966,1980; Kistler and others, 1981; Snoke, 1980, 1997; MacCready and others, 1997. Mineral deposits: (1) Valley View Mine, W, Pb, Zn skarn; (2) Battle Creek Mine, W, Pb, Zn skarn; (3) American Beauty Mine, Pb, Zn, Ag skarn; (4) Knob Hill Mine, Pb, Zn quartz vein; (5) Summit View Mine, Pb, W, Cu skarn; (6) Judy Mine, Ba, bedded barite; (7) B & P claims, Ba, vein .

Table 2. General geologic and metallogenic succession in the Ruby Mountains, Nevada

Period	Geologic events	Mineralization
Cenozoic	Faulting mylonitic transition zone granite-monzonite intrusion	Barite vein, replacement Amphibole-garnet-epidote skarn W+Pb, Zn, Cu, Ba (as late celsian)
Mesozoic	Granitic intrusion folding metamorphism	Pyroxene-idocrase skarn W+Pb, Zn, Cu, Ag, Ba (as earlier celsian and late barite)
Middle and Late Paleozoic	Epicratonic carbonate and clastic sedimentation	Bedded barite (SEDEX)
Early Paleozoic		Speculative barite-base metal SEDEX

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